ARMY RESEARCH LABORATORY

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

ARL-TM-2008a August 2008

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14. ABSTRACT

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

All college undergraduate and graduate students receiving research appointments and conducting summer studies at ARL are automatically enrolled in the symposium program. As an integral part of their summer study, all students are required to write a paper on their work which summarizes their major activity and its end product.

The program is conducted on two separate competitive levels: undergraduate and graduate. The format of the paper in both levels is the same. However, the evaluation will take into consideration the difference in the academic level of the students.

All students submitted their research paper for directorate review. Directorate judging panels selected two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 7 August 2008.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 7 August 2008. At the symposium the students presented their papers to the ARL Director and an ARL Fellows panel.

This volume of the Summer Student Symposium Proceedings contains the abstracts for all papers prepared for the Summer Student Symposium Program.

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Director's Foreword

The Army Research Laboratory (ARL) mission is to "Provide innovative science, technology, and analyses to enable full spectrum operations." As the Army's corporate laboratory we provide the technological underpinnings critical to providing capabilities required by our current and future Soldiers.

Our nation is projected to experience a shortage of scientists and engineers. ARL recognizes the criticality of intellectual capital in generating capabilities for the Army. As the Army's corporate laboratory, addressing the projected shortfall is a key responsibility for us. We have therefore identified the nation's next generation of scientists and engineers as a key community of interest and have generated a robust educational outreach program to strengthen and support them. We have achieved many successes with this community, and believe that the breadth and depth of our outreach programs will have a significant positive effect on the participants, facilitating their journey toward becoming this Nation's next generation of scientists and engineers.

A fundamental component of our outreach program is to provide research experiences at ARL to students. During the summer of 2008, we supported research experiences at ARL for over 100 undergraduate and graduate students. Each of these students was required to write a paper describing the results of the work they performed while at ARL. All of the papers were of high quality, but only a select few could be presented at our student symposium. The abstracts for all papers prepared this summer are contained in this volume of the proceedings and they indicate that there were many excellent research projects with outstanding results. It is unfortunate that there was not enough time for us to have all of the papers presented. We would have enjoyed hearing them all.

We are very pleased to have hosted this outstanding group of students for the summer. It is our hope that they will continue their pursuit of technical degrees and will someday assist us in providing critical technologies for our Soldiers.

Introduction

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

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Hierarchical Structure Design for Biologically Inspired Gecko Adhesives

Baek, Stanley S.

In this work, I demonstrate the effect of hierarchical structures of nano-fibers in conforming to a range of rough surfaces using equivalent linear spring models for synthetic nano-fibers and Gaussian random rough surface. I discuss the limitations of a single layer fiber array depending on surface roughness using computer simulations, as well as the improvements and limitations of the conformity of hierarchical nano-fiber structures to surfaces with macroscale waviness and microscale roughness. I also present further improvements by integrating piezoelectric actuators along with force sensors with hierarchical nano-fiber structures. We predict that the number of fibers in contact with a rough surface, such as a painted drywall, can be improved by an order of magnitude.

The author wishes to acknowledge the mentorship of Jeffrey Pulskamp and Ronald Polcawich.

Numerical Prediction on Remaining Project Allocation Units

Bailey, Brittney

In order to best plan the use of their computer allocation resources, it is important for groups in the ARL MSRC to be aware of their project allocation usage, particularly in the cases of under- and overutilization of resources. Underutilization could indicate that a group is having trouble with its project or will have a significant amount of allocation units remaining at the end of the fiscal year. Overutilization indicates that a group may not have enough allocation units remaining to complete or continue its project. Groups are notified in each case so they can plan accordingly for the remainder of the year. Their plans may include adjusting the use of their resources, requesting additional allocation units, or perhaps receiving help for any trouble they are having. The goal of this project was to predict the project allocation units remaining for a group at the end of the fiscal year, and to flag the data for under- and overutilization. A script was developed to monitor, predict, and report the rates of usage for each group and the data was presented both graphically and as an excel document for ease of interpretation.

The author wishes to acknowledge the mentorship of James Ianni.

Anechoic Chamber Calibration and Field Level Measurements

Bamba, Amid

Anechoic chambers are designed to provide a controlled electromagnetic environment that will allow accurate antenna measurements to be made with virtually no inner or outer electromagnetic interference or reflections. In this paper, I will present calculated and collected gain measurements of three different antennas inside of a tapered chamber structure at UHF frequency bands between 400Hz to 500Hz and 1GHz to 2GHz. This paper addresses as a well-established method of measurement called the Three Antenna Method; which I used to determine the gain of the antennas and how the gain of the antennas can be adversely affected by variables such as the environment, impedance, and polarization mismatched. This paper will also include collected gain and radiation pattern measurements of a standard gain horn antenna at the Ka band (30–40 GHz) that will be established at the center portion of the tapered chamber structure as a function of three different heights.

The author wishes to acknowledge the mentorship of Youn Lee.

Telemetry Basketball – "D-Ball"

Baumgartner, Adam

VAPPS (Very Affordable Precision Projectile System) is an experimental weapon designed by engineers at the Army Research Laboratory. Its distinguishing feature is a pair of canards on the front of the round which enable the weapon to change its direction in flight. The angle that these canards adjust to is critical to the accuracy of the weapon. As a result, a device designed to calibrate or zero the canards needed to be developed.

The Rotational Calibration Device or RCD uses laser reflection to measure the angle of the canards with an accuracy of $1/17^{th}$ of a degree. The RCD is also portable, lightweight, and is very easy to use. The laser light reflects off the canards, and by measuring the reflected laser light's location, one can use trigonometry to find the angle that the canard is at and calibrate it. Also, the RCD features an innovative space saving design to reflect the laser light off a set of mirrors to increase the precision of the device. This paper is a proposal detailing the engineering that went into its design.

Characterization and Improvements to Porous Silicon Processing for Nanoenergetics

Becker, Collin

Nano-porous silicon offers a large surface area to volume ratio typical of nano materials and contains a network of pores that can be filled with oxidant. When a silicon fuel source is combined with an oxidant on the nano-scale, kinetic limitations of silicon oxidation are overcome and an explosive reaction is realized. We present a characterization of lightly doped p-type silicon for nanoenergetic porous silicon (PS) applications. Using gas adsorption measurements and gravimetric techniques, we characterize pore size, porosity, specific surface area, and thickness of PS thin films. Additionally, we report on the energetic reaction of the PS/oxidant system and mechanical stability of PS formed under several etch conditions including varied etch current, drying techniques, and annealing. Prior research has not focused on sample preparation methods of PS for gas adsorption measurements, but results presented here indicate that the method of PS sample preparation for gas adsorption isotherm analysis impacts the results. We find that a newly reported gravimetric technique for PS parameter characterization is inconsistent with expected PS property trends for lightly doped p-type Si.

The author wishes to acknowledge the mentorship of Luke Currano.

A Simplified Model to Predict Secondary Response at Seat Mount Location due to Impact on Primary Structure

Beg, Sara

In this experiment, I evaluated the performance of a seating system in protecting an occupant during a change in velocity of a vehicle due to a vertical impact (i.e., a mine blast). I performed a drop test analysis to simulate a change in velocity at the seat mount location of the vehicle and used a simplified spring-mass model to estimate the change in velocity at the seat mount due to the motion of the seating support system. Experimental results show that approximating the change in velocity using this simplified approach requires further assessment of a spring-mass model to better approximate the change in velocity at the seat mount location on the vehicle.

The author wishes to acknowledge the mentorship of Dr. Mostafiz Chowdhury.

Development of a Miniaturized Photoacoustic Chemical Sensor

Bender, John S.

The detection and identification of chemical warfare agents and hazardous industrial chemicals has become a priority for military and homeland defense applications. Therefore, urgent need exists for a portable chemical sensing platform to increase battlefield survivability and decrease collateral damages. Current work focuses on the development of a miniaturized photoacoustic chemical sensor using a quantum cascade (QC) laser in combination with microelectromechanical systems (MEMS)-scale photoacoustic cell designs. Two photoacoustic cells were investigated, each producing detection limits for dimethyl methylphosphonate (DMMP), a standard nerve agent simulant, below 15 parts-per-billion (ppb), and the minimum detection limit for the system is 7(±2) ppb. Results suggest that sensitivity can be increased by incorporating an acoustic filter design into the sample delivery pathway of the cell and that continued development of a miniaturized photoacoustic sensor is viable.

The author wishes to acknowledge the mentorship of Dr. Ellen L. Holthoff.

Demonstration of a Multiplexed Electrospray Micromachined in Silicon Substrates for Fuel Atomization

Boniche, Israel

This paper reports the design, fabrication and testing of multiplexed electrospray (ESpray) devices micromachined in silicon substrates for portable power systems. Additionally, an experimental test-stand was developed to facilitate testing. Through the atomization or breaking down of fuel into finer droplets, this design aims to increase the efficiency for liquid hydrocarbons and enable the use of JP-8 diesel in miniaturized combustion systems such as gas heat engines and microcombustors. The microfabrication of ESpray prototypes requires standard photolithography and deep-reactive ion etching (DRIE) of silicon. Precise alignment and assembly of silicon nozzle and extractor layers is accomplished with optical fibers embedded between the surfaces of each layer. To demonstrate electrospraying, devices were first tested using Ethanol over a range of applied voltage and flow rates. Although limited by space-charge effects, 19-nozzle devices (12.5mm x 12.5mm x 1mm) demonstrated flow rates of 0.50 ml/hr/nozzle and 0.35 ml/hr/nozzle for 90 µm and 75 µm outer diameter (O. D.) nozzles, respectively, with a 1 kV potential difference (and a $7x10^5$ V/m removal electric field) between the layers.

The author wishes to acknowledge the mentorship of Brian Morgan and Mike Waits.

Microstructural Characterization of Pure Bulk Tungsten

Breneman, Ryan

In this effort, I used the equal-channel angular extrusion (ECAE) process method to explore the grain refinement of tungsten (W) to alter its high-rate deformation failure mode. Such processing strongly depends on uniform and consistent properties in the starting material; however, I found that the microstructures in commercial bulk W vary significantly. I analyzed pure W rod from three suppliers using grain size analysis, Vickers microhardness analysis, and direct observation with scanning electron and optical microscopy. Upon the discovery of inter-granular fracturing, I added four additional lots from one of the manufacturers to gauge the scope of the problem. Results showed broad inconsistencies in grain size and microstructure between suppliers, lots, and even sections of a single piece of material. Material from one supplier showed a clear, predictable, symmetric pattern indicative of homogenous processing, while the material from the other suppliers possessed microstructures varying in an unpredictable asymmetric manner. However, despite the morphological variations, the microhardness across all samples tested fell approximately within one standard deviation. The knowledge and insight gained from this work will help to guide future purchasing decisions and processing strategies for W for use in high-rate deformation applications.

The author wishes to acknowledge the mentorship of Suveen Mathaudhu.

Structure-Dependent Fracture Properties of Thermosetting Polyurethanes

Chan, Jason

In the process of selecting an adhesive material for the interconnection of bonded structural components, numerous factors must be taken into consideration. A wide variation exists among adhesives in such properties as strength, ductility, yield strength, elongation to failure, durability, environmental resistance, and ease of manufacturing. Component interconnections in some structural applications require an adhesive that can withstand mechanical loading at high strains rates and can function durably in a broad range of environments. Thermosetting polyurethanes may be useful in this application because of their high strength and ductility. The goals of the research project are two-fold. The first objective is to design a bonded joint suitable for determination of both Mode I tensile and Mode II shear adhesive strength properties from the same specimen, which may allow for reduced sample preparation burden. The second goal of this project is to determine if the linear viscoelastic properties of a family of polyurea thermosetting adhesives, by systematically varying the equivalent weight of the oligomeric diamine component, obeys universal response as the test temperature (T) is held constant in relation to the glass transition temperature (T_g).

The author wishes to acknowledge the mentorship of Robert Jensen.

Carbon Nanotube-based Differential Amplifier Circuit

Chin, Matthew

Carbon nanotube-based field effect transistors (CNTFETs) show potential in the area of integrated amperometric sensors due to high sensitivity (<ppm) to analytes, fast response times (seconds to minutes), and large surface area-to-volume ratios. This report proposes the design, fabrication, and testing of a CNTFET-based differential amplifier that can achieve a nominal gain of 20 dB. Differential amplifiers possess the benefits of low-noise, low-distortion, and small signal amplification making them ideal for sensor applications. Building upon early results, methods for improving circuit design and device fabrication are explored.

The author wishes to acknowledge the mentorship of Dr. Steven Kilpatrick.

Bulk Synthesis of Carbon Nanotubes by Chemical Vapor Deposition

Choi, Daniel

Carbon Nanotubes (CNTs) were grown using a chemical vapor deposition (CVD) process that used a catalytic decomposition of CH_4 over a catalyst composed of Fe, Mo, and an Al_2O_3 base. CNTs were grown in a quartz tube heated at 900 ^oC. A mixture of CH_4 and Ar was fed in the quartz tube for 30 minutes following an Ar flow for 45 minutes. The process yielded sizable quantity of CNTs grown in the catalyst containing quartz crucible. The "as-grown" nanotubes (NTs) were then analyzed by Raman and Mössbauer spectroscopies, transmission electron microscopy (TEM), and scanning transmission electron microscopy (STEM). The TEM and STEM images show a mixture of single-walled (SW) multi-walled (MW) NTs. The Raman data suggests the presence of (8, 8) and (9, 9) SWNTs, MWNTs, and other graphitic materials, not clearly identified. The Mössbauer spectra of the as-grown sample suggest the presence of different phases of magnetic Fe nanoparticles in contrast to a single paramagnetic phase present in the catalyst before thermal treatment. Further optimization of the CVD parameters for growing SWNTs is in progress.

The author wishes to acknowledge the mentorship of Dr. Shashi P. Karna.

Structural Response for Armor Panels Due to Blast: Generation of a Response Database for Use in Vulnerability Analysis Codes

Ciappi, Raquel

Blast effects on armor panels of Army ground vehicles are modeled and compiled to create an archive of structural responses for Survivability/Lethality Analysis Directorate's (SLAD's) vulnerability analysis codes. The archive is mainly concerned with values of blast pressure impulse and the corresponding panel deflection. This effort is part of a larger SLAD effort for flat, wedge, and curved panels of different angles, panel size, and materials. The effort presented here is concerned only with Rolled Homogeneous Armor (RHA) wedge panels, while the larger effort encompasses curved panels. For each panel size, seven wedge angles each with eight wall thicknesses were computed. The finite-element stress analysis code ALGOR was utilized. The structural response for the panels is computed with emphasis on determining both the blast pressure impulse that will cause the panels to structurally fail (fracture), and the maximum deflection of the panel. Effort for the other panels and parameters is continued currently by SLAD's personnel toward the goal of continuously populating the blast response archive.

Self-Patterned Growth of Branched Structures Via Electro-Hydrodynamic Hele-Shaw Flow

Cutler, Julia L.; Palmese, G. R.; Wetzel, E. D.

Current research aims to find effective means of creating biomimetic vascular systems for polymeric composite materials. This research project explores one method for growth of branching structures. Motivation is taken from electrical treeing and viscous fingering phenomena. Applying these basic principles, the aim of this project is to combine Saffman-Taylor instability with an applied electrical potential in order to grow and control branching patterns in a curable polymeric system and create a finely and complexly branched channel. Increasing the viscosity ratio of the matrix and injection fluid increases the degree of branching and decreases droplet formation from the structure. Adding surfactant works to decrease the interfacial tension between these fluids and decreases droplet formation at the expense of some degree of branching. Increasing the voltage applied to the system increases branching, although also increases the amount of droplets. Flow rate must be finely tuned in order to avoid pooling in the channels. The goal of this research project can be met by tuning these parameters and casting the final product in a UV curable vinylester epoxy resin.

A MATLAB-based GUI for the Anderson-Darling Statistic

Davis, Kelly; DeGele, Elizabeth

Many statistical methods are developed under the assumption that the data to be analyzed follows a specific distribution. Therefore, the procedures to determine if these distributional assumptions are met, provide an important preliminary step in statistical analysis. Although several tests have been proposed to test for normally distributed data, one test, the Lilliefors test for normality, has been used extensively in several U.S. Army Research Laboratory (ARL) programs during recent years. Despite the accuracy with which the Lilliefors test determines normal data, the Anderson-Darling test has proven more powerful at distinguishing deviations from normality. The creation of a MATLAB-based Graphical User Interface (GUI) allows the user to easily apply the Anderson-Darling test to analyze univariate data sets of any size for normality. The GUI can also be used to determine which of several candidate distributions provides the best fit to the data set. Such a program will greatly enhance productivity while providing a more accurate analysis for data essential to ARL's mission.

Dielectric Characterization of Composite Systems for Dynamic Loading

DeVillier, Andrew

This research project developed a fast and simple method of characterization for ceramic, polymer composite, and ceramic-composite materials systems. Current methods, such as ultrasonic scanning, provide high resolution information but consume considerable time. Using a parallel plate capacitor setup, the capacitance, quality factor, and dielectric constant of a material sample can be measured through the thickness of the composite. Data is collected incrementally at 1-inch intervals and displayed as a false-color image map of the sample. This experimental setup can be easily scaled from single ceramic tiles to large panels about 6 square feet while accommodating a variety of thicknesses. Automation will further enhance our capabilities to quickly characterize a large amount of samples. Currently, only a few samples have been characterized after undergoing dynamic loading, and, therefore, data comparing measurements before and after is sparse. Continuation of this project should provide sufficient data to determine the correlation between change in capacitance, quality factor, and dielectric constant values with damage sustained and possible defects, helping determine if certain samples are more prone to failure than others before being used under dynamic loading conditions.

The author wishes to acknowledge the mentorship of Matthew Bratcher.

Preliminary Report on Determination of the Upconversion Coefficient of ErYAG Via Z-scan

DiBiano, Robert

Upconversion in Er YAG is a significant loss mechanism, and in order to predict/model this behavior an accurate value of the upconversion parameter Cup is necessary. Absorption in this material is a nonlinear process, i.e., at higher intensities, there is less absorption. This causes the crystal to appear more transparent to pump light at higher intensities. Upconversion refills the lower pumping level and inhibits this bleaching process somewhat. How much less bleaching is observed than the 'expected' value without upconversion can be used to calculate the upconversion coefficient.

A simple and accurate way to measure the nonlinear absorption of a material is to move a thin sample of the material through the focal point of a focused laser beam, measuring the total transmission through the sample at each point in the beam; this is known as a 'z-scan'. This experiment attempts to use an open aperture z-scan to calculate the nonlinear absorption, and therefore, the upconversion parameter of Er YAG pumped at 1532nm. Using z-scan data and MatLab code for calculating the expected nonlinear absorption of Er YAG at a given Cup, error between theoretical and experimental results can be minimized while varying Cup, allowing Cup to be calculated.

The author wishes to acknowledge the mentorship of Jeff White.

Robotic Intelligent Control System with Human Inspired Plan Selection

Dimperio, Eric

Recent psychological models of decision making go beyond stating how rational agents should act. They offer an explanation of why people make decisions that seem irrational. One such model is the Decision Field Theory (DFT). This model describes decisions as a diffusion process where preferences for each alternative change. Unfortunately, DFT has only been used to explain specific data sets in highly controlled environments. Certain aspects of the theory have not even been tested together. This article describes an implementation of DFT within a robot simulator as a test environment for transition to a physical robot. Results show that in a more complex environment with repeated decisions, DFT needs to be augmented to allow for more naturalistic behaviors.

The author wishes to acknowledge the mentorship of Troy Kelley.

Hydrophilic/Hydrophobic Patterned Surfaces via Diels-Alder Chemistry

Dirlam, Philip T.

Hydrophobic glass surfaces were created through a stepwise functionalization process utilizing Diels-Alder chemistry as the primary linking avenue. A carboxy-maleimide was synthesized and esterified with perfluorinated alcohols to be used as the dieneophile in the Diels-Alder reactions. Amine terminated surfaces were created using a simple silanization process which were then functionalized with a furan group to act as the diene in the Diels-Alder reactions. Once attached via Diels-Alder linkage, the perfluorinated esters demonstrated a great hydrophobic property with potential for reversal via cleavage of the Diels-Alder linkage.

Effects of Differing Carbon Nanotube Field-Effect Transistor Architectures

Dorsey, Andrew

Single walled carbon nanotube field effect transistors (SWCNT FETs) were fabricated with varying device architectures. Variations on the standard backgated architecture used in previous research included varying gate oxide thicknesses, carbon nanotube suspension which minimizes interaction with the gate oxide, and a top-gated architecture employing a thin layer of Al_2O_3 as the gate oxide. Devices were characterized and compared to each other based on the CNT FET properties of hysteresis, sub-threshold slope, and threshold voltage. Results show that some properties of the CNT FETs, such as hysteresis, can be modified; however, other properties are intrinsic to the carbon nanotube.

The author wishes to acknowledge the mentorship of Dr. Matthew Ervin.

Transcription Start Site Mapping Using Primer Extensions

Dupuy, Nicole

Locating transcription start sites on mRNA is crucial to better understanding how regulatory mechanisms work in biological systems. Current methods used to find these sites are costly, time-consuming, and pose safety concerns with their use of radioactive materials. This study demonstrates a new technique, using primer extensions to locate start sites, that is faster and can accommodate more samples. First, DNA was used to test this concept and found to work with extreme accuracy. Later, the technique's accuracy in locating known RNA start sites was tested. Further development of protocol for the technique will soon be preformed, leading to its eventual use in finding unknown promoter start sites.

The author wishes to acknowledge the mentorship of Dr. Christian Sund.

SiGe 30 GHz, 1 W Power Amplifier

Farmer, Thomas

Using a commercially available silicon germanium (SiGe) bipolar complementary metal oxide semiconductor (BiCMOS) .13 um integrated circuit (IC) technology, I set out to design simulate, and lay out a power amplifier operating at 30 GHz that could produce an output power of approximately 1 W. Achieving a 1 W of output power is the technical challenge of this work, since power amplifiers previously designed at 30 GHz in SiGe have only obtained an approximately 250 mW power output. To achieve this output power, I proposed a unique circuit design that required no alterations to the commercial SiGe process.

The author wishes to acknowledge the mentorship of Edward Viveiros.

Optimization of Handheld Assays for the Implementation of Novel Recognition Elements

Faulkner, Kasey; Finch, Amy

The rapidly emerging and evolving landscape of biological hazards requires new technology to develop detection methods against emerging threats. It is essential for the U.S. Army to be able to identify biologically hazardous material in food, the environment, and biological tissues. Currently, researchers are working to use peptide libraries to rapidly determine affinity reagents, rather than the present method of producing monoclonal antibodies in living animals that can take months. The affinity reagents developed from peptide library can then be combined into a compact handheld device that uses a lateral flow assay to detect hazardous biological materials. The lateral flow assay uses latex nanoparticles tagged with C-reactive protein (CRP) antibodies as well as gold nanoparticles tagged with CRP antibodies to test the ability of affinity reagents to identify target antibodies.

Evaluation of Novel Thermoset Matrix Composite Materials for Tailored Mechanical Performance

Fischer, Brandon; Mulkern, Thomas

An evaluation of thermoset matrix composite materials is part of a major effort to find alternatives to the S-2 glass/SC-15 epoxy composites currently used in military platforms. In this report, we describe the evaluation process of novel thermoset matrix composite materials for improved/tailored mechanical performance. This report describes four types of mechanical testing that were performed: short-beam shear strength testing, flexural property testing, tensile property testing, and end notched flexure testing for interlaminar fracture properties. The study generated the following mechanical property data for each S-2 glass composite: short-beam strength, flexural strength, modulus of elasticity, ultimate tensile strength, and mode II strain energy release rate; this data which will be entered into a large mechanical properties database that is being compiled. Improvements over the legacy matrix were observed in several instances; however, based on the results to date, there is no single candidate material to replace the legacy matrix material. Future testing will include drop tower impact and compression testing. Mechanical property data will also be generated for these materials at a number of extreme environmental conditions in order to fully characterize their performance under extreme temperature and humidity conditions.

Development of MEMS Piezoelectric Rotational Actuators

Gee, Danny

For the Soldier, size and power limitations of equipment in the field are critical for mobility. To address these concerns, micro-electro-mechanical systems (MEMS) are being developed to replace conventional systems with smaller, more efficient devices. Despite its prevalence in nature and intrinsic efficiency, rotational movement has been largely neglected in MEMS research. In this work, an in-plane piezoelectric MEMS rotational actuator has been demonstrated, which provides free deflections up to 2.25°, requiring a bias of <15V and a current of ~0.2nA. The resulting power consumption is four orders of magnitude less than existing electrothermal rotational designs with similar deflections. The actuator uses the low-power, high-force characteristics of lead zirconate titanate (PZT) and an offset-beam design to achieve rotational or near-linear translational deflections. A piezoelectric stack of 1μm of PZT layered between platinum electrodes is fabricated on a 2μm SOI wafer. The device is patterned by milling and released. Upon application of an electric field, the transverse piezoelectric effect causes the two offset beams to contract, thereby creating a torque about a bridge that connects the two beams. Device imperfections specific to residual stresses are discussed, and a supporting finite element model is presented.

The author wishes to acknowledge the mentorship of Luke Currano.

Power Converter Design for the Power for Microsystems STI

Gehrels, Thomas

The Army is pursuing the development of microsystems capable of increasing the situational awareness of the warfighter. Due to the small size of microsystems, providing power will require combinations of batteries and energy harvesters capable of drawing energy from the environment. The presence of multiple, variable power sources, in addition to the changing power requirements of the microsystems, creates the need for an intelligent interface between power sources and loads, which has led to the Strategic Technology Initiative to develop such interfaces. This work investigates power converters in order to optimize efficiency, gain and size/weight. Additionally, feedback control techniques will be investigated in order to provide an adaptive interface to the dynamic system.

Power converters included in this paper focus on switched inductor designs. A selection guide is developed for picking appropriate components used in these converters for maximum efficiency. The variables in the selection guide offer an understanding of which parameters can be changed to decrease the size/weight of the converter. In order to determine the functional requirements for a feedback control circuit, the effect of a changing input voltage, output load and gain requirement on the required control signal and overall efficiency are measured.

The author wishes to acknowledge the mentorship of Dr. Brian Morgan.

Design and Construction of a Low Reynolds Number Aerodynamic Performance Analysis Tank

Gerdes, John

As part of the U.S. Army's initiative to improve situational awareness of the Soldier in the battlefield, unmanned aerial vehicle (UAV) technology has emerged as a major research topic. The purpose of this study is to create a force analysis testing environment to facilitate the development and optimization of a micro-scale flapping wing. Additionally, other devices exposed to low Reynolds number flows, including fixed wing technology can also be analyzed using this apparatus. With the resulting optimized wing designs obtained from this testing apparatus, UAVs will be lighter, more efficient, and have greater endurance, thus directly benefiting the Soldier through improved situational awareness.

Experimental Laboratory Environments: Image and OCR Tool Kit (IOTK) Utility Exploration

Giffen, Nicole; Hernandez, Luis; Briesch, Douglas

This research effort explored computer software that acts as an environment for image processing and optical character recognition (OCR) investigations to see if the software would increase the efficiency for experimentations in this domain. A prototype tool kit called Image and OCR Tool Kit (IOTK) was used and a database created from previously collected and scanned representative document pages. We performed a series of automated and manual tests using multiple OCR engines and the results were timed, scored, analyzed, and compared. In addition, the usability and effectiveness of the tool kit as a processing, experimentation, and testing environment was evaluated using conventional methods. The findings and recommendations are provided to further the refinement of this prototype environment.

Moving Towards an All Optical Network

Granger, Zamon

An optical switch is a layer two network device that enables optical data signals to be selectively switched from one circuit to another. The current network is comprised of fully loaded standard electronic equipment that has connections made with optical fiber and UTP copper wire. In researching optical switching, I discovered that there are many outstanding attributes of the technology. Optical switches can create an almost infinite free flow of data signal when compared to the current equipment. As this technology evolves, it creates many great possibilities such as uniting clusters of computers so that synchronized performances can be executed concurrently. Though sufficient for now, when desktop computers begin to produce data at a rate which exceeds 10 gigabyte, it would be beneficial to implement optical switches into the network.

In addition to my research I received tutorials on many subjects ranging from a hands-on demonstration of cable crimping to the relevance of binary numbers in networking applications. I attended presentations hosted by various vendors such as Cisco and Force 3 at there respective regional offices. I also learned how to install and configure the new smart UPS system and replace the UPS chassis, networking cards, and batteries.

The author wishes to acknowledge the mentorship of Colleen Adams.

Patterning of Thick Parylene Films by Oxygen Plasma for Application as Exploding Foil Initiator Flyer Material

Grapes, Michael D.

The U.S. Army Research Laboratory (ARL) is developing smart, exploding foil initiator fuzes using Microelectromechanical systems (MEMS) technology to reduce the fuze footprint within the warhead and increase safety by allowing the use of insensitive explosives. Parylene-C has been chosen as the flyer material for the exploding foil initiator; therefore, a method for patterning parylene is required. In response to this demand, a process for patterning thick (>10µm) films of parylene using a thin (~100nm) metal masking layer and oxygen plasma has been developed. Gold and titanium have been compared as masking materials on the basis of masking quality and compatibility with existing materials and processes. Etch rate, directionality, and minimum feature size have been approximated for isotropic and anisotropic oxygen plasma etch recipes. Remaining obstacles to process integration are discussed.

The author wishes to acknowledge the mentorship of Eugene Zakar.

A Projectile/Target Interaction Study of Confined Ceramics

Gray, Joshua

The Projetile/Target Interaction (PTI) study was developed to determine the dwell/penetration transition velocity, penetration rate, and depth-of-penetration for ceramic armor materials in a simple target configuration. Sub-scale tungsten heavy alloy (WHA) long-rod penetrators were fired into these targets at velocities ranging between 800–1800 m/s. The target configuration established a baseline in which the effect of subsequent variations in materials and target configurations on fundamental performance could be determined. For these experiments, the effect of different ceramic materials were investigated. The diameter and thickness of the ceramic cylinders was 38.1 mm. The cylinders were slip-fit into Ti-6Al-4V cups, and a thin Ti-6Al-4V cover plate was welded on to the top of the cups. In this configuration, the Ti-6Al-4V cup provided only lateral confinement, but no lateral pre-stress. Post-mortem destructive characterization in previous tests revealed the apparent cause was the formation of steep cone cracks. The experimental set-up, methodology and results are discussed.

The Virtual Computer

Griffin, Domonique

Scientists are constantly collaborating on projects to assist Soldiers. The engineers at CISD wanted to create a network that would allow scientists to collaborate using a secure network. This resulted in a virtual network or Integrated Distributed Research Network (IDVRN). This works by allowing scientists who are internal and external to the Army Research Laboratory (ARL) to connect computers, software, and other equipment to the IDVRN. There are numerous measures that will be taken to ensure that the IDVRN functions as a secure environment. This summer I worked with several engineers and researchers from CISD to set up the IDVRN to ensure that it meets the approval of the Information Assurance Manager, the scientists who will be using the IDVRN, and their partners.

I assisted in the setup and installation of VMware on the main server for the IDVRN. I also worked on the problem of how to successfully install and operate a personal computer in the workplace that has VMware installed on the computer as the main operating system.

The author wishes to acknowledge the mentorship of Colleen Adams.

Process and Properties of Bio-rubber Modified Vinyl Ester Resin

Grous, Alexander; McAninch, Ian; La Scala, John

Vinyl Ester (VE) resins are commonly used in polymer matrix composites (PMC) because of their low cost and, when modified, their desired mechanical properties. Some modified resin systems need a higher styrene content to reduce their high viscosity caused by the modifiers. A low HAP-modified VE system created at Drexel University may be a viable option for PMCs. During some process', longer working times are needed for the PMCs infuse, this can be achieved by altering the initiator packages. In the case of this bio-rubber toughened VE system, the altering of initiator packages to lengthen and shorten the working time was done and its mechanical properties were evaluated to see if there were any changes. Glass transition temperature was found to vary some but more importantly the fracture toughness of the resin was maintained and was still greater then that of the neat resin.

Ceramic Tile Dimensions and Impact on Subsequent Tile Array Gapping

Hamblin, Stacey; Jessen, Todd

This study presents an experimental investigation on a new approach to measuring silicon carbide (SiC) tile dimensions and the gaps between these tiles within an array. In this work, we characterized the SiC tiles using a standard flatbed scanner at 1200 dots per inch (dpi), calculating and applying a correction factor to account for distortion of the scanner bed. We then explored the gap thickness between SiC tiles within arrays using two methods, light intensity and gap measurements. The collected data suggests that there is a correlation between the measured light intensity and spaces between the tiles.

Photogrammetry Technique for Deformation Measurement of Millimeter-Scale Wings

Harrington, Aaron; Kroninger, Christopher

Measurement of objects using photographic images is a technique known as photogrammetry. This method uses known camera and lens parameters to map points identified in pixels on two or more image planes to points in a 3D object space. This technique was applied to measure the deformation of an insect-scale wing as it is actively flapped. Using specialized photogrammetry software, photographs of the wings were analyzed, and predetermined titanium targets on the wings were programmatically located and measured in pixel space. Using the collinearity equations, these points were transformed and measured in object space. The method used to accomplish this is outlined, as well as basic photogrammetric theory and techniques.

Stress-driven Surface Instabilities in Solids with Diffusing Charged Defects

Henke, Steven

Stress-driven rearrangement instability (SDRI) theory postulates that diffusion in stressed solids can lead to surface morphological instability. This effect is believed by many physicists to be real and important for elevated-temperature deposition or annealing of thin films. Both atomic surface diffusion and bulk diffusion of point defects contribute to the instabilities.

The stress-driven diffusion of mobile oxygen vacancies in the bulk is especially important in ferroic perovskite films, e.g., Barium Strontium Titanate, which have desirable optical and electric properties for device and sensor applications, and often require well-controlled surfaces and interfaces. We present a continuum reformulation of the SDRI theory that includes the coupled electro-elastic diffusion of oxygen vacancies and describe a 3D finite-element scheme for solving the equations of film surface evolution. In the coming months, we will explore the stability of the film boundary due to perturbations and attempt to characterize the incipient instabilities in terms of the model parameters.

Adhesion Pre-treatments for Ceramic Materials

Ho, Christine; Jessen, Todd

Adhesion is critical to assembling the many different materials types that comprise composites. This study explores the use of an ultraviolet-ozone treatment, as well as argon/oxygen plasma as pre-treatments on bonding surfaces. Boron carbide and silicon carbide tiles have been the focus of this study. The effectiveness of the pre-treatment has been determined by contact angle measurements. Half-wedge mechanical test have also been initiated as a part of this study. Overall, plasma treatments appear to be the most effective means for preparing the surface for bonding.

Performance of Super-Resolution Enhancement for Flash LADAR Data

Hu, Shuowen

As the U.S. Army continues its transformation towards an objective force, robots will contribute to the Soldier's increased lethality, survivability, and sustainability. Using laser detection and ranging (LADAR) for robot navigation and obstacle avoidance is an active area of research. Traditional scanning LADAR systems used for robotic applications only acquire two-dimensional imagery and are typically bulky. A new generation of three-dimensional LADAR devices, called flash LADAR, may provide a cost-effective solution for robot navigation. The high frame rate, wide field-of-view, and low cost of flash LADAR are key advantages over scanning LADAR in urban indoor settings, but at the cost of spatial resolution.

The objective of this work is to apply super-resolution image reconstruction to enhance the resolution of flash LADAR data. I developed a preprocessing stage that uses wavelet edge filtering to increase the accuracy of sub-pixel shift estimates for improved image registration. To assess the improvement in image quality due to super-resolution, I conducted a triangle orientation discrimination behavioral (TOD) experiment at various target ranges to provide a human subjective measurement. Results show that the super-resolution of flash LADAR data increases probabilities of target discrimination over a wide range while decreasing response times.

The author wishes to acknowledge the mentorship of S. Susan Young, Ph.D.

Design and Testing of a Long Endurance Unmanned Arial Vehicle Thrust Vectoring System

Janas, Alex

This paper details the design, programming, and testing I did on a two-motor propulsion system for a highly maneuverable, long-endurance unmanned aerial vehicle. The design I selected utilizes passive fins in conjunction with two hollow shaft motors supporting variable pitch propeller, which are mounted such that they are able to rotate about the pitch axis. The use of a thrust force stand allowed for motor calibration. Control test results stem from the use of a roll-axis thruster testing platform that will be upgraded later to support yaw-axis motion.

Neural Net Control of a Hyper-redundant Robotic Manipulator

Jaworski, Joseph

This document details the control and design of a hyper-redundant tentacle manipulator. The autonomous control is being accomplished through the use of a neural net. The tentacle takes on a biologically inspired design looking like a vertebrate backbone and having modular vertebrae units. Virtual simulation of the arm is planned to take place in an Unreal Tournament.

Direct Methanol Fuel Cell Technology

Johnson, Diana

A current problem in Direct Methanol Fuel Cell technology involves the development of a membrane to separate the cell's electrodes. This membrane must be able to conduct protons while limiting methanol permeability to conserve fuel and reach full cell potential. Our research tested an acid- base polymer composite membrane composed of poly-(2-acrylamido-2-methylpropanesulfonic acid), 2-aminobenzamidazole, and poly-(vinyl alcohol) to attempt this as well as to create a membrane without the need for hydration. The most ideal membrane developed consisted of a 1:1 ratio of acid: base polymer with a 50 weight % poly-vinyl alcohol composition. Further research needs to be conducted to successfully cross link the membrane and characterize its properties using conductivity testing, thermogravimetric analysis, and chemical stability testing. With a successful membrane prototype, Soldiers will be able to carry more efficient and lighter power sources into the field.

Network Visualization

Jones, Danielle

Data visualization is a field many only associate with tables, graphs, and charts, but new techniques are being engineered to show data in a more profound and creative way. The visualization of data will make the review of large collections of data more comprehensible to the common user and not just the scientist. It could possibly facilitate earlier logic error detection and clearer debugging solutions. The Army Research Laboratory (ARL) has a scientific visualization team at Aberdeen Proving Ground (APG) dedicated to the development of visualization methodologies for the Department of Defense. The team develops new and novel techniques to assess and analyze physics-based scientific data generated on the supercomputers at the ARL Major Shared Resource Center (ARL MSRC) and captured from the Defense Research Engineering Network's (DREN) high speed networks. The Python code is written to populate a database with packet information parsed from a network simulator session. The database will be the basis for the software Paraview to work from to visualize the data.

The author wishes to acknowledge the mentorship of John Vines.

Development and Characterization of an Optimized Elastic Layer for PZT Based Switch Actuators

Jones, Paul

There is currently a strong need to improve the robustness of the lead zirconate titanate (PZT) actuators as well as provide a means with which to increase both the contact force and restoring force. One way of achieving this is through improving the elastic layer beneath the PZT actuators. This project characterized several new elastic layer composites that can be used for the actuators. The layers were comprised of various silicon dioxide and silicon nitride multi-layer composite stack structures. Cantilevers comprised of the new composites and platinum (Pt)/PZT/Pt) actuators were fabricated using a combination of reactive ion etching, metal deposition, and xenon difluoride (XeF_2) etching. Characterization of the cantilevers included residual stress deformation by optical interferometry and deformation as a function of applied voltage. Further characterization will include piezoelectric coefficient analysis and resonance frequency analysis.

The author wishes to acknowledge the mentorship of Jeffrey Pulskamp.

Evaluation of Polymeric Positive Temperature Coefficient Devices to form Degradation Algorithms

Keaney, Kenneth

Polymeric positive temperature coefficient (PPTC) devices have been known to degrade gradually after being faulted excessively. This project is designed to discover exactly how and at what rate PPTC devices degrade. Our objective in finding this information is to fault these "resettable fuses" repeatedly at a variety of currents. In doing so, gradual degradation can be examined. When sufficient data has been acquired an algorithm will be created to exhibit the rate of decay and properly analyze the trend.

Currently, sufficient data has been presented to make a series of conclusions regarding the degradation and device characteristics. However, additional analyses are still necessary.

The author wishes to acknowledge the mentorship of Kwok Tom.

Material Methods & Processes for Transparent Ceramics

Kierzewski, Iain

In my studies I have been introduced to ceramic materials technology. I have developed an understanding of the fundamental processing aspects of ceramic materials with a focus in transparent ceramics.

The author wishes to acknowledge the mentorship of Dr. James Sands.

Database Creation for Information Processing Methods, Metrics, and Models (DCIPM3)

King, Kevin; McVey, Michelle C.; Murray, Sean; Slocum, Christine

One challenge of tactical information processing within the demanding net-centric environment is the fusion of data extracted from various free form message[1] databases. The development of high level data fusion products addresses this challenge. However, development relies heavily on the availability of large, accurate datasets. This report documents the Database Creation for Information Processing Methods, Metrics, and Models (DCIPM3) project that creates, from an ARL designated context, a realistic detailed scenario encompassing a multitude of social interactions. A Time Ordered Event List (TOEL) was created from the scenario that includes references to multiple forms of communication[2], events, and interactions between subjects. An extensive message set was then derived from the TOEL that includes verbal and textual communication between subjects. Web Ontology Language (OWL) was used to create an ontology populated with information from the message set. Resource Description Framework (RDF) triples may be extracted from this ontology. The resulting database can be used by the information fusion community when both a known social context and a comprehensive database of messages to support that context are required.

[1]Free form messages include semi-structured and unstructured verbal, digital, and textual communication.

[2]Forms of communication include face-to-face verbal communication; digital communication such as text messaging, instant messaging online, and telephone conversations; as well as written textual communication such as personal letters.

Fast Curing Underwater Adhesives

Klankowski, Steven; De Bonis, Daniel; La Scala, John

A good underwater adhesive needs to be able to cure quickly in different aquatic environments, while still forming a strong bond between substrates. Dry adhesion testing showed that Epicure 3271 with M Cure 400 diacrylate cured into a hard solid with a strong bond within a few minutes. Other notable formulations for fast curing included the Epon 8111 and Epicure 3271, which also cured within 5 min and produced a strong bond. We constructed an underwater testing apparatus to measure the bond strength of fast curing formulations. Our results showed that Lord Acrylic Adhesive 403 performed well as an underwater adhesive, curing within 15 min to obtain good bond strength. Future work will examine methods based on dry curing studies in order to reduce the cure time.

Analysis of Ground Vehicle Test Data

Klein, Brittany

AMSAA has performed seeded-fault testing on Light Medium Tactical Vehicles (LMTV) at Aberdeen Proving Grounds and Yuma Proving Grounds. In these tests, LMTVs were driven on the course with engine coolant removed, the engine or transmission oil removed, or the radiator blocked. The LMTVs were equipped with nCode data-acquisition boxes, which monitored the vehicles' status with a variety of sensors. Data from these tests were obtained, and the results from the coolant and radiator tests were used to form an algorithm that indicates the duration of overheat when it occurs in the engine.

Further analysis will be performed to determine how overheat can be observed with other sensors. Future use of nCode boxes in the field will provide data describing vehicle conditions in a variety of situations. This will build a foundation for the development of usage profiles that will aid in reduction of uncertainty in feature extraction and prognostication of remaining useful life for a given vehicle.

The author wishes to acknowledge the mentorship of Andrew Bayba.

Ixia 400T Traffic Generation

Knopp, Daniel

The Ixia 400T can be used to simulate user traffic on the network, and any problems that may arise can be identified quickly. Various applications such as VoIP, video, and E-mail traffic can be simulated, as these are commonly used. Attacks can be replicated in a test environment. IPv4 and the more recent IPv6 are supported.

For my summer project, the Ixia was planned to be used for testing of an IBM enterprise server. The chassis is a Windows XP PC with up to 32 network ports on the front. Some ports include their own Linux processors to better process test data. Simply link the 400T via Cat-5 cable to a client PC (to administer tests) and insert the chassis in the chain of whatever component(s) are subject to the testing. Beginning with setting up the chassis and software, I ran a few preliminary HTTP tests: simulating various amounts of user traffic and generally getting to know the program suite. Then, the maintenance expired and I spent the next few weeks attempting to no avail to get the programs to be functional. However, it seems possible to get the set up working again for further testing. I have been in contact with an Ixia representative who has been assisting me in troubleshooting some installation problems I have experienced. The program suite is easy to use once operational; the software requires an annual license. This seemed to be much more difficult than expected to maintain.

While the Ixia seems to be a robust machine, the corporation of Ixia needs to refine their licensing system, as weeks have been spent loading, unloading, and registering the software in order to obtain a functional system. The testing process could not be completed because of a lengthy delay in the maintenance request and the award (yet to be received). The programs are very comprehensive; almost any type of network simulation involving traffic can be replicated here.

The author wishes to acknowledge the mentorship of Jeanne Angelini.

Developing Tensile Test Methodology for UHMWPE Laminates

Krus, Tyler

Laminates made from high performance ultra-high molecular weight polyethylene (UHMWPE) fibers, such as Dyneema HB2, offer a high strength-to-weight ratio and large energy absorption capability. These characteristics make it ideal for personnel protection. However, other than literature from the manufacturer, there are few publications available on the material properties of UHMWPE laminates. More so, reports on the experimental methodologies used to characterize these materials are not fully detailed. I developed a novel experimental technique to mitigate the otherwise problematic interply shear failure at the grips during tensile tests of Dyneema HB2. In addition to this technique, I also applied digital image correlation (DIC) in order to more accurately measure the axial strains.

The author wishes to acknowledge the mentorship of Paul Moy.

Transparent Nanoporous Glass/Polymer Composites

Lawrence, Bradley D.; O'Brien, Daniel J.

Currently, the materials available for transparent applications are limited to a handful of polymers and ceramics, thus only a narrow range of mechanical properties are available. In this work we manufacture a novel transparent polymer-glass composite by infiltrating nanoporous glass (Vycor, Corning Inc.) with different polymers. The Vycor pores (4-6 nm) are much smaller than the wavelength of light, thus refractive index matching with the polymer is not necessary for transparency. We infused purified Vycor glass with four different monomers and polymerized them using benzoyl peroxide as an initiator. The samples were removed and polished, and their mechanical and qualitative properties assessed (polymerization time, degree of Vycor penetration, cloudiness, discoloration, hardness, and fracture toughness).

Exploration of Alternative Surface Characterization Techniques for Bulk Thermoplastic Systems Loaded with Hyperbranched Polymer Additives

and

Synthesis and Characterization of Novel Polyurethane Thermoplastics for High Impact Applications

Lee, Michele

This report will focus on two different areas of study: Exploration of alternative surface characterization techniques for bulk thermoplastic systems loaded with hyperbranched polymer additives (Project I) and Synthesis and characterization of novel polyurethane thermoplastics for high impact applications (Project II), with more detail and attention placed on the former project due to incompletion of the latter project.

Project I: Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy were examined as complimentary techniques to X-ray photoelectron spectroscopy (XPS) for surface analysis of hyperbranched polymer (HBP) additive loaded bulk polymer matrices. Host polymer matrices examined include poly(methyl methacrylate) (PMMA), Estane, and X-1150. FTIR and Raman spectra were obtained for pure additive, pure host polymer, and 5% loaded host polymer specimens. Data from each instrument exhibit an overshadowing of surface HBP signal by the host polymer signal, suggesting that the radiation depth of penetration used to collect data is too great. FTIR and Raman spectroscopy were shown to lack the sensitivity needed to accurately discern the HBP level of surface segregation.

Project II: The effect of varying the molecular weight of a polyurethane soft segment, its choice of chain extender, and the order of reactant addition during synthesis on resultant microstructure was investigated. Chain extenders include butanediol (BDO), hydroquinone (HQ), and triptycene-1,4 hydroquinone (IPT). Due to the added bulkiness of the IPT propeller-like structure and aromatic rings, produced polyurethane is expected to exhibit energy-dissipative properties. Simultaneous reactant addition is also expected to strengthen the resultant polyurethane against high impact deformation due to an increase in phase mixing of the hard and soft segment domains. Mechanical properties will be analyzed using dynamic mechanical analysis (DMA) multiple frequency testing and single frequency temperature sweep capabilities.

The author wishes to acknowledge the mentorship of Joshua A. Orlicki.

The Study of Lu_2O_3 Powder Processing and Sintering

Lidie, Ashley

This report discusses the powder processing and sintering of Lutetium Oxide (Lutetia). A study was conducted to determine the workability of pre-processed powder from various companies. Based on results the powder required further processing, such as dry ball milling and colloidal processing, in order to meet the requirements. Next the process called for optimization of sintering to achieve the highest density material. Using a dilatometer and microscopy to analyze the results, a master sintering curve will be constructed for Lutetia, but the study is still ongoing. The current results show that the powder needed to be finer in order to achieve a higher sinter density. Dry ball milling is much more efficient for achieving a smaller particle size than the colloidal processing. The highest sinter density along with the smallest grain size seemed to be the formula for success. The goal is to generate Lutetia for a laser hosting application with a high degree of light transmittance with low optical scatter. To achieve this goal the process requires optimization to produce the highest quality material. If this can be achieved, there is a possibility of generating a new market for laser host materials.

The author wishes to acknowledge the mentorship of Gary Gilde.

Effect of Biofilm Formation on Microbial Fuel Cells

Mackie, Timothy

Microbial fuel cells produce electrical current by exploiting the metabolic cycle of anaerobes and collecting the electrons generated during anaerobic respiration that are not scavenged by other oxygen acceptors. Ideally, more free electrons can be captured if the cells are forced to grow a biofilm directly on the anode surface. In this experiment, I treated microbial fuel cells inoculated with *Bacteroides fragilis* with the biofilm inducing quorum sensing molecule, N-hexanoyl-DL-homoserine lactone. After a 24-h incubation period, I analyzed the treated fuel cells for biofim formation and increased voltage output. I found no discernable differences between the treated cells and the negative controls. Further research is needed to establish which substances can successfully induce biofilm formation in *B. fragilis.*

The author wishes to acknowledge the mentorship of Dr. James Sumner.

Patterned Metal Thin Film Catalyst for Carbon Nantube Growth

Magagnosc, Daniel

The growth of single walled carbon nanotubes (SWNTs) from patterned metal thin films was the focus of this investigation. In the study, patterned metal thin films were optimized for SWNT growth through chemical vapor deposition (CVD). Standard photolithography processes were used to pattern metal thin films to catalyze SWNT growth. Starting with a nickel-aluminum bilayer, the effect of different film compositions and oxygen plasma treatments was investigated. The growth conditions used during CVD were also considered in order to maximize the density of SWNTs. It was determined that 10 nm aluminum supporting 1 nm of nickel yielded the best growth when treated in a 20 minute oxygen plasma.

The author wishes to acknowledge the mentorship of Dr. Barbara Nichols.

Design of Mini-Compressed air Horizontal Accelerating Device (Mini-CHAD)

McQuaid, Patrick

This report provides an overview of design and fabrication of the Design of Mini-Compressed Air Horizontal Accelerating Device (MINI CHAD). A MINI CHAD, with the ability to shoot a rock ranging between 1.27 and 3.81 cm (.5–1.5 in.) in diameter at a velocity between 11.176 and 44.704 m/s (25–100 mph). The MINI CHAD is designed to simulate a rock coming up from a High Mobility Multipurpose Wheeled Vehicle (HMMWVor Humvee) tire tread at an assumed normal operating speed.

The author wishes to acknowledge the mentorship of Peter Dehmer.

Improvements of Techniques and Devices for Survivability, Lethality, and Vulnerability Analysis

Meraz, Nathan

The Survivability/Lethality Analysis Directorate (SLAD) recently built a spectrometer that was able to capture sensor irradiance at 500 fps with 5 nm intervals over a 600 nm bandwidth range. This spectrometer was used to characterize the physical and optical properties of obscurants; a computer processing tool was developed for this system to determine the transmittance of an obscurant with respect to wavelength and time. Three optical systems have been designed to function alongside the current spectrometer to assist in the development of narrow bandwidth technologies as part of the ongoing SLAD effort to characterize signatures and study obscurant effects on sensor performance.

The author wishes to acknowledge the mentorship of Joseph Montoya.

Design of an Indoor Quadrotor

Moses, Allistair

The U.S. Army Research Laboratory (ARL) Vehicle Technology Directorate (VTD) quadrotor project aims to create an aerial vehicle capable of operating indoors and in areas typically devoid of global positioning system (GPS) data. Moreover, the vehicle must be capable of operating in an environment without preliminary site preparation. The aircraft itself is based on the commercial DraganFlyer vehicle, and consists of four propellers arranged in an X pattern, driven by brushless direct current (DC) motors. The primary control strategy selected is a proportional-integral derivative (PID) controller. While this may be sufficient for short duration flights, inertial measurement unit (IMU) drift ultimately leads to failure in indoor environments. Averting this requires an external reference. While traditional vehicles utilize GPS, in GPS denied areas, computer vision typically provides the best solution. In the past, vision processing was performed by transmitting data from an on-board camera to a ground station, which then calculates and transmits attitude corrections to the vehicle. This method requires a reliable communications link between the vehicle and the ground station that is not always possible. For this reason, the ARL-VTD quadrotor is capable of performing vision processing independent of a ground station, which should be sufficient to achieve autonomous indoor vehicle operation.

STEP, APG Site – Building Molecular Crystals with Defects for Atomistic Simulations

Munday, Lynn

This report outlines the initial development of an atomistic model of the condensed phase energetic material hexahydro-1,3,5-trinitro-1,3,5-s-triazine (RDX) crystal to be used in studying the response to shock loading in the vicinity of crystal defects. In this work the atomistic model of the RDX molecular crystal is built and embedded with various point, line and surface defects using the Multiscale Simulation Application Suite (MSAS) (1). MSAS is used to build the RDX crystals from RDX structural data given by Choi (2) and then an elastic solution is used to embed vacancies, dislocations, or grain boundaries. Once the geometry of the grain, crystal structure and defects are input into MSAS, a data file is created and converted to a format used by other programs, such as the classical molecular dynamics code Large-scale Atomic/Molecular Massively Parallel Simulator. These models will be used in simulations to study molecular vibrations and phonons in the vicinity of defects and their coupling to intramolecular vibrations, and dislocation motion in the vicinity of defects. The work fits into a larger program investigating processes that effect hot spot formation and shock induced detonation.

The author wishes to acknowledge the mentorship of Dr. Peter Chung.

Ion Implantation Activation of GaN for Ohmic Contacts and P-N Junctions

Nguyen, Cuong

We will study ion implantation activation in Gallium Nitride, a wide bandgap semiconductor. Our goals are to determine if we can reduce the ohmic contact resistance to n-type GaN using silicon implants and to create a p-n junction using magnesium implants. The following pieces of equipment or methods will be used during our research: 1) an MOCVD growth system will be used to grow GaN on sapphire 2) Atomic Force Microscopy (AFM) will be used to determine the RMS roughness of the GaN surface affected by the annealing 3) Scanning Electron Microscopy (SEM) will also be used to examine the GaN surface 4) Photolithography will be used to create patterns that will be implanted 5) an E-Beam Evaporator will be used to deposit layers of metal on a patterned surface of GaN 6) a furnace will used to anneal the wafer for the purpose of activating the implanted ions 7) Electrical measurement such as Hall, Van der Paul and TLM will be conducted to determine the mobility, carrier concentration and sheet and contact resistance of the annealed GaN.

The author wishes to acknowledge the mentorship of Dr. Kenneth Jones.

Thermomechanical Evaluation of Thermoplastic Matrix Composites

Nowrey, Thomas A. IV; Mulkern, Thomas

This study evaluated the performance of thermoplastic matrix, carbon fiber composites against that of an epoxy matrix, carbon fiber composite. We used thermomechanical testing over a desired temperature range of 160 to 350 degrees Fahrenheit, observing the effect of the environment on the mechanical properties at elevated temperatures. These tests included short-beam strength, flexural, and tensile testing. In addition to the mechanical testing, we conducted thermal analysis tests via dynamic mechanical analysis and differential scanning calorimeter techniques and used. These tests to compare the glass transition temperatures of the two materials and to better define the operating temperature ranges of each. The data demonstrate that at ambient temperatures the thermoplastic is comparable in mechanical properties to the thermoset material. At elevated temperatures the composite degrades, which is a desired response for a specific application.

Antenna Array for a Compact Radar Using MEMs PZT Phase Shifters

Patterson, Chad

The clash between stealth and enemy detection is an ongoing battle that has motivated much of the technological advancements in radar systems. Historically, most of this effort has been geared toward engineering large, expensive, industrial sized radars that are immobile. However, for the Soldier on the battlefield, these types of radars become ineffective when equipment must be easily transported on a frequent basis. Resolving this problem has spawned a new generation of mobile radar systems that are compact, light-weight and low-cost.

This paper discusses a novel antenna array for a compact radar that achieves a scan angle of 90 degrees with a beam width of 9 degrees in the azimuth plane and 18 degrees in the elevation plane. The radiating aperture is comprised of a 4 x 8 microstrip rectangular patch array. The array is excited through a complex feed network operating at a center frequency of 9.1375 GHz with a bandwidth of 75 MHz. Electric scanning is accomplished by PZT MEMs phase shifters developed by ARL. The integration of the antenna array, feed network and active components (MEMs phase shifters) poses various problems when trying to develop an optimal electrically scanning array.

This project is still undergoing simulations and testing. A final design has been submitted for fabrication and is expected to be received August 2008. This design will then undergo tests on a vector network analyzer and in an anechoic chamber.

The author wishes to acknowledge the mentorship of Dr. Steven Weiss.

Development of a Health Indicator for Roller Bearings

Petre, Karl

There is a wide variety of signal processing techniques appropriate for the prognostics and diagnostics of mechanical systems. Such methodologies may be applied for the detection of faults in helicopter drive train components, where the degradation of bearings is of particular interest. The health of these components is typically monitored by assessing their vibration signatures; vibration data is acquired via accelerometers placed in the vicinity of the bearings.

I will apply numerous signal processing algorithms in an attempt to aid development of a health indicator for roller bearings. This investigation will be based primarily on data gathered by health and usage monitoring systems (HUMS) installed on fielded UH-60 helicopters.

The author wishes to acknowledge the mentorship of Dr. Romeo del Rosario.

Vertical Shock Investigation of Energy Absorbing Mechanism for Occupant Safety

Pritchett, Justin

Anti-Tank (AT) mines and Improvised Explosive Devices (IED), when detonated, induce high levels of mechanical shock to a vehicles structure and to the occupants inside. The M1A3 Abrams tank serves as the main battle tank of the U.S. Army. The scope of this report encompasses an investigation of the efficiency of an energy absorbing mechanism for the M1A3 gunner seat subjected to vertical shock loads. An energy absorbing mechanism is designed as an effort to decelerate the occupant in a manner which the applied loads are humanly tolerable. Using a honeycomb structured material, a crushable column energy absorber mechanism is designed and positioned between the floor and seat pan of the seat. Two different geometries of energy absorbers (EA's) are assembled to the gunner seat, equipped with an Anthropomorphic Test Device (ATD), and tested on a vertical shock machine. Previously determined baseline tests prove that the EA's are effective in decelerating the occupant to humanly tolerable loads. At a drop height of 35 inches, the EA reduces the Pelvis DRIz below the human tolerance level. Future work and development with EA design and additional testing will continue the effort of making advancements for the occupants' safety in the M1A3 Abram tank.

The author wishes to acknowledge the mentorship of Morris Berman and Dr. Mostafiz Chowdhury.

Comparison of Gold/Platinum and Gold/Ruthenium Contacts on Piezoelectrically Actuated RF MEMS Switches

Proie, Robert

U.S. Army Research Laboratory (ARL) lead zirconate titanate (PZT) radio frequency (RF) microelectromechanical systems (MEMS) switches were fabricated with half of the switches on each wafer (approximately 30 switches), using the typical gold/platinum contacts and the other half using gold/ruthenium contacts. Several import parameters were measured using an Electroglass automated probe station including contact resistance, pull-in voltage, and bias current. The switches were cycled a number of times and the measurements repeated. In addition, samples of five switches of each type were cycled to failure and the mean output voltage was logged to assess the effect of these contact materials on the lifetime. The measurements were then analyzed in order to determine if ruthenium contacts were a viable alternative to platinum. Wafer-to-wafer variability remains to be tested.

The author wishes to acknowledge the mentorship of Daniel Judy.

Study of Gap Distribution in Ceramic Hexagon Tile Arrays Part I: Theoretical Analysis

Rajpal, Taig

Modern ceramic armor systems are being made of large flat arrays of ceramic tiles that are tightly nested arrays with gaps between them. The ceramic arrays use hexagonal tiles that are known to have inconsistency in gap widths, which compromise the ballistic integrity of the panel. These gaps are due to manufacturing and processing errors. This study is the first step into understanding where these gaps originate and how to minimize them. I used Solid Works to model a single imperfect tile in an array to see the effects on gap distribution and propagation. I initiated the imperfection with an error in length of parallel sides without changing the angles of the hexagon. I then exaggerated the size of the error to better visualize the effects. The results suggest that a tile that is cut short does not propagate gaps, whereas a larger tile does. This investigation is a first step to identifying the tolerances of tile manufacturing as well as predicting the size of gaps in future armor panels.

The author wishes to acknowledge the mentorship of Seth Ghiorse.

Magnets for Use in Self-Assembly

Raju, Akshay

Self- assembly technology is integral in finding solutions for rapid assembly and integration of micro- and nano-components for military systems. Magnetic forces from a hard magnetic thin film can be used to bond micro-scale components in a self-assembly process. There are many types of hard magnetic films each with different magnetic properties that can be used in self-assembly. However, CoNiMnP hard magnetic thin films allow the use of electroplating at room temperature instead of high temperature annealing (>450 °C) which can harm many materials used in microelectromechanical systems (MEMS). Soft magnets, which only have magnetic forces if there is a magnetic field, are a perfect complement to the hard magnet for uses in self-assembly. After establishing a hard magnetic template, soft magnetic film components such as Permalloy can be attached via self-assembly with magnetic forces. In the end, CoNiMnP and Permalloy (NiFe) were deposited with thicknesses ranging from 1-9 μm. The magnetic remanence of the CoNiMnP material was 2.8 mA/m. These materials allow continued research on the use of self-assembly to organize micro-scale components into larger structures.

The author wishes to acknowledge the mentorship of Dr. Christopher Morris.

Diffusion Barriers for Adatoms in Growth of Quantum Dots

Ramsey, James

This work uses molecular statics simulations to estimate the performance of empirical potentials in determining energy barriers in adatom diffusion. Barrier values are to be used in kinetic Monte Carlo (KMC) simulations of growth of InAs quantum dots on a GaAs substrate. Calculated values are compared with available density functional theory (DFT) predictions. The molecular statics simulations model the motion of an adatom over an InAs film on a GaAs substrate. The adatom is moved in small steps along a path from one binding site to another, and the potential energy and adatom height along this path are obtained. The Tersoff potential is used in these simulations and its quality is evaluated for two parameter sets (Hammerschmidt et al., *Physical Review B*, v. 77, 235303, 2008; Migliorato et al., *Physical Review B*, 65, 115316, 2002). Molecular statics appeared unreliable overall for determining energy barriers, but of the two parameter sets, the results using parameters from Hammerschmidt et al., appeared closest to the results from DFT calculations. Planned future work includes DFT calculations following a methodology similar to that of this work in order to more directly test the value of the molecular statics calculations.

Design of a Mini-Autonomous Ground Vehicle with Independently Actuated Suspension

Rice, Joseph; Karna, Parthesh

In this paper, we describe the design and construction of an autonomous platform that will navigate indoors without the use of Global Positioning System (GPS). To accomplish this, we used a highly modified version of the Traxxas E-Maxx. This modified version included a novel, independently actuated suspension to navigate complex terrain and stairs. We added four-wheel steering to increase mobility and perception hardware, which includes a scanning laser range finder with tilting axis and a stereo camera for obstacle avoidance and navigation using Simultaneous Localization and Mapping (S.L.A.M.). We used a PC-based Nano-ITX motherboard as the controller which was powered by a Lithium Ion 24V, 6.2Ah military battery.

Novel Techniques for Improving Optical Performance of Transparent Composites

Ridley, Jason I.; O'Brien, Daniel J.

There has been an increasing need for composite materials for a number of U.S. Army applications due to their impressive strength-to-weight ratio. Moreover, it is possible to create optically transparent polymer composites with glass reinforcement to improve their mechanical integrity. The transparency of the media is governed by refractive index (R.I.) matching of the constituents in the composite. Changes in temperature, however, create a refractive index mismatch between the polymer and glass fibers. This increases the scattering of incident light, and leads to a drastic reduction in transparency of the material. We propose a passive and active solution to address this problem. The passive solution involves the implementation of a nanocomposite interphase region that creates an index of refraction step between the mismatched constituents of the media. This is achieved by coating the glass fibers with silica nanoparticles via self-assembly, and allowing the polymer of the composite to infiltrate the void interstices of the nanoparticle network. The active solution involves the loading of the non-linear optic (NLO) dye 4,4'-methoxynitrostilbene (MNS) into an R.I.-tuned epoxy mixture. This makes the composite material electro-optically active, and can therefore tune the refractive index with an applied electric field.

Pressurize Structured Aircraft Extended Flight Duration Power System Research

Ross, Wayne

The power system for an unmanned aerial vehicle (UAV) is any component onboard the UAV that stores and consumes electricity. Essential to the UAV's ability to fly for extended periods are efficiently designed and managed power systems that will supply the energy to maintain the lift that the UAV requires. UAVs designed without an internal combustion engine are particularly problematic; therefore, efficient power systems are more critical in UAVs propelled by electric motors. I explored the different types of energy that could possibly be used to extend flight duration and investigated some ways to incorporate multiple sources, for example, batteries and solar cells. I designed algorithms to monitor the vehicle and based upon its state, intelligently instruct its energy usage in the most efficient manner.

Polymer Materials for Ground Mobile Millimeter-Scale Robotics

Rudy, Ryan

This project is closely tied with the ongoing work of visiting Professor Kenn Oldham and the U.S Army Research Laboratory's joint effort on creating highly flexible, large payload capacity joints for a ground mobile millimeter-scale robot. We characterized the fabrication process to add parylene coatings to the PiezoMEMS actuator process using test structures. On two separate fabrication sequences, we completed scanning electron and optical microscopy of the joint assemblies; analysis of the coating technology for trench fill; process robustness to exposure to solvents and photolithographic processing; and adhesion of parylene to both platinum and lead zirconate titanate (PZT) thin films. We successfully applied parylene coatings to both platinum and PZT thin films and we evaluated the challenges associated with parylene survival with multiple fabrication process steps. Future work will include full release of test structures on the existing wafers in fabrication as well as implementation of process improvements into a full functional Piezo Micro Electro Mechanical Systems (PiezoMEMS) plus parylene actuator joint.

The author wishes to acknowledge the mentorship of Dr. Ronald G. Polcawich.

Characterization and Improvements to Porous Silicon Processing for Nanoenergetics

Salaets, Natalie

This report will evaluate different methods of depositing carbon nanotubes (CNTs) from solution onto a silicon substrate to make CNT field-effect transistors (FETs). The goal of this deposition is to obtain reproducible device properties due to more uniform tube densities and other traits. Characterization of the CNT films will be done with the scanning electron microscope and atomic force microscope. The CNTs will be processed into FETs using cleanroom techiques. The resulting devices will be characterized using a semiconductor parameter analyzer to measure their electrical properties. A comparison of the results for each deposition method will help determine which approach is useful for producing CNT devices for chemical sensing electronic applications.

The author wishes to acknowledge the mentorship of Dr. Matthew Ervin.

Optimization of PbTiO3 Seed Layers and Pt Metallization for MEMS Actuators

Sanchez, Luz M.

Sol-gel lead zirconate titanate (PZT) material properties are inherently linked with its crystallinity and texture. The use of seed layers and control of the base metal crystal structure ultimately controls the ferroelectric and piezoelectric properties of the thin film. This research transferred the lead titanate ($PbTiO_3$) seed layer fabrication process that was recently accomplished at Penn State University under a fiscal year 2007 (FY07) Army Research Office (ARO) Short Term Innovative Research (STIR) to the U.S. Army Research Laboratory (ARL). The seed layers and PZT thin films along with cantilever actuators were fabricated using the ARL radio frequency (RF) microelectromechanical system (MEMS) switch fabrication process. Thin film samples were characterized with X-ray diffraction to measure the texturing within the film, and the ferroelectric, dielectric, and piezoelectric properties were measured and compared to samples currently used in the fabrication of RF switches and robotic actuators. X-ray diffraction data confirmed the presence of (001) oriented $PbTiO_3$ seed layers, which were used as a template for (001) oriented PZT in order to increase the piezoelectric coefficient with a goal of a 50% improvement in low field properties. Material property measurements are currently underway and will be reported at the conclusion of the project.

The author wishes to acknowledge the mentorship of Ronald Polcawich.

Direct Digital Synthesis Technology for the Personnel Avoidance Radar for Robotic Vehicle Application

Schmidt, Scott

A major problem for autonomous robotic vehicles operating in urban environments is personnel avoidance. Radar technology can provide position and velocity information of personnel to a moving vehicle with accuracies sufficient for urban operation. Direct Digital Synthesis (DDS) technology can be used to generate the necessary software configurable waveforms to support this requirement.

My research assesses the performance of the 9910 DDS chip to verify that it will meet the requirements of the Personnel Avoidance Radar. In addition, I extended this research by studying the effects of the number of bits used in controlling the ramp generation on the quality of the waveform used in radar signal processing. Specifically, I characterized the impact of varying the number of bits on the range compression and radar imaging by simulating with MATLAB the linear frequency modulated waveform produced by the AD9910.

The author wishes to acknowledge the mentorship of Marvin Conn.

TGP and Centrifuge Design

Sharar, Darin

DARPA is working towards producing high-power electronic cooling systems as an approach for improving power component efficiency. One avenue they are researching is TGP (Thermal Ground Plane), technology that uses nanostructure technology and two-phase heat transfer. DARPA has contracted several companies and academic establishments to develop various TGP technologies tailored for various high-power electronics applications. To test their progress, DARPA has organized three development phases known as Phase I, Phase II, and Phase III. Various metrics including hermeticity, wicking at 2g, 10g, and 20g loads, thermal expansion mismatch, wick thermal conductivity, TGP thermal conductivity, TGP thickness, area, weight, and duration are outlined for each phase.

The Army Research Laboratory has been contracted by DARPA to build a test apparatus that is capable of testing and reporting these metrics. This necessitates the production of a centrifuge that is capable of: 0-20g inertial loads, maximum flexibility for variable TGP mounting, temperature and acceleration measurements, data acquisition, data transfer, and results analysis with integrated diagnostics. The following report discusses background on TGPs, theory on centrifuges, and analyzes the design features of the centrifuge and a Lexan® safety shield.

The author wishes to acknowledge the mentorship of Dr. Brian Morgan and Nicholas Jankowski.

Using Molecular Dynamics to Model Phase Transition in $BaTiO_3$

Solomon, Jose

The focus of the current work is to develop a new parameterization of the shell model potential for molecular dynamic (MD) simulations of the tunable dielectric $BaTiO_3$ (BTO). BTO is a versatile ferroelectric crystalline material with a wide range of applications; consequently, modeling its material response through computational simulations is an active field of research. The current effort focuses on developing new parametric values for the shell model by which to accurately predict phase transition in BTO as a result of changes in bulk lattice temperature. Although the literature presents a number of studies in which parameters for the shell model implementation of BTO are given, in general these parameterizations are not able to capture with the desired accuracy the phase transition temperature at which all four crystalline phases of BTO occur. The aim of the current work is to, therefore, generate a more robust parameterization through the use of genetic algorithms (GA). Using a database, derived from density functional theory (DFT) analysis, consisting of unit-cell lattice geometries and their corresponding configuration energies, the GA strives to evolve new parameters for the shell model that allow the potential's functional form to agree with the DFT energy landscape. Using this technique, a set of parameters will be evolved that will capture phase transition with greater fidelity.

Filament Winding of Composite Helmet Preforms

Sorensen, Ryan

This paper discusses the modeling and fabrication of composite helmet “preforms” using the filament-winding fabrication process. Such preforms are intended to be inserted into a molding process (which is beyond the scope of this work) for final consolidation. Experiments validate the accuracy of the model, showing that the thickness of a filament-wound helmet preform wall can be tailored by selecting an appropriate combination of winding layers.

The author wishes to acknowledge the mentorship of Ryan Emerson.

Hazardous Air Pollutant Free Thinners For Rubber To Metal Adhesives

Stabler, Christopher B.; Toulan, F. Raven; La Scala, John

Chemlok 252X and Thixon 532-EF are adhesives used to adhere rubber to metal for the treads on tanks at the Red River Army Depot. Toluene and xylene are hazardous air pollutant (HAP) solvents that are used to thin these adhesives for spray and dip adhesive application. These thinners are dangerous to the environment and the people using them. A HAP-free thinner would be favored to replace currently used thinners. Various HAP-free thinners were tested as an alternative to toluene and xylene. The tested thinners, except isopropanol and ethanol, were soluble in both adhesives. The viscosities of the zero HAP thinned adhesives were all fairly similar to the toluene and xylene thinned adhesives. Thermogravimetric analysis established that 80-90 percent of the wet solution's mass evaporates upon reaching temperatures between 75-100°C. The dry times for the HAP-free dilutions were within the dry times for the toluene and xylene thinned adhesives, allowing for a convenient transition to the HAP-free thinner. Using the vulcanized rubber substrates, the optimum cure time for maximum adhesion is 24 hours. Through testing of solubility, dry time, adhesion, and viscosity, it was determined that acetone, methyl acetate, MEK, and tert-butyl acetate are solvents that could potentially replace the hazardous solvents currently being used.

Synthesis and Characterization of the Diblock Copolymer PS-POEM

Terrell, Julie

The purpose of this research was to synthesize controlled molecular weight block copolymers consisting of poly(methyl methacrylate) (PMMA) and poly(styrene) (PS), and poly(ethylene glycol) methyl ether methacrylate (POEM) and PS. These copolymers may support ionic conductivity while retaining structure, and have potential use in ionic applications such as lithium batteries. Gel permeation chromatography (GPC) was used to calculate the mass average, the number average molecular weights of each polymer block, as well as the final product. Synthesis was done to alter the amount of reactants to produce varying size polymers, and reaction times were adjusted to influence size. The relative sizes and interactions of the blocks will influence microphase separation and morphology, mechanical properties, and ion transport, studies of which are imminently underway.

The author wishes to acknowledge the mentorship of Dr. James Snyder.

Target Geometry Conversion

Thompson, Justin

Industry produces many of the ground systems that the U.S. Army places in theater. Often industry distributes target geometry to the U.S. Army Research Laboratory (ARL) in Pro/E format; therefore, it is necessary to convert the Pro/E geometry to BRL-CAD geometry for use with the Survivability/Lethality Analysis Directorate (SLAD) vulnerability model, MUVES. A number of modifications must be made to the Pro/E geometry before the BRL-CAD conversion tool can be used. Using specific examples from a recent project involving a variant of Mine Resistant Ambush Protected (MRAP) vehicle, I have documented many of the processes required for a smooth transition of the target geometry from Pro/E to BRL-CAD.

An Analysis of the Acoustic Sniper Localization Problem

Toher, Liza

In this report, three localization scenarios for acoustic sensing of a sniper event are presented. First, we discuss the challenges of the general sniper localization problem (SLP) using acoustic sensors and derive Cramér-Rao error variance bounds for the multiple scenarios: muzzle blast or shockwave time of arrival (TOA) and time-difference of arrival (TDOA) of muzzle blast and shockwave. Second, we abstract the SLP to a distributed sensing and computing problem. Third, using the Cramér-Rao bounds, we then develop possible realizations for mobile networks, that is, sensors and distributed data fusion algorithms on a per Soldier basis. Lastly, we will present specific spatial distributions of Soldiers and compare their localization capabilities.

The author wishes to acknowledge the mentorship of Gene Whipps.

Source Code Vulnerability Assessment Methodology

Villa, Diana

Coding errors and security vulnerabilities are routinely introduced into application source code for both malicious and non-malicious purposes. The U.S. Army Research Laboratory (ARL) Survivability/Lethality Analysis Directorate (SLAD), Information and Electronic Protection Division (IEPD) has developed a security-focused source Code Analysis Methodology (CAM) to identify, exploit, and mitigate vulnerabilities found in software developed for use in U.S. Army systems. Because of the classified nature of the results obtained via the CAM on actual systems, it is not possible to present these results in an unclassified forum. Instead, the work presented here provides a proof-of-concept of the CAM and exploit development process by generating an exploit for a buffer overflow vulnerability found in a free software application. A buffer overflow vulnerability presents a serious threat to the security of a software system and provides one example of the coding errors and security issues that the CAM is designed to detect, exploit, and mitigate against. The work described here provides an example of the process that is followed to ultimately determine the appropriate mitigations and countermeasures that will protect and enhance Soldier and system survivability via the CAM.

The author wishes to acknowledge the mentorship of Daniel Landin.

The Quantification of *Clostridium cellulolyticum* using RT-PCR

Walker, Alyssa

Methods currently used for the quantification of microbes that adhere to substrates such as cellulose include protein content analysis and nitrogen analysis which are insufficient for the needs of scientists today. *Clostridium cellulolyticum* was used as the model organism since it adheres to cellulose. In this experiment, I used Real Time- PCR to quantify the bacteria based on their DNA content. Real Time- PCR is preferred in this case to traditional PCR because of the continually updated progress of your sample. Growth studies were done to determine whether RT-PCR and regular cell counts correlated. The graphs indicate that it is possible to determine when the different phases of cell growth occur and how many bacteria are present at those times. This method is very promising in providing a fast and easy way to quantify these cells.

The author wishes to acknowledge the mentorship of Christian Sund.

Study of the Ballistic Limits of Plywood Human Surrogates Impacted by Fragments and the Effect on Personnel Evaluation

Weaver, Kate

In this study, I examined the data collection medium, ¾ inches marine grade plywood, which is currently used for crew casualty assessment for fragmenting munitions. This medium can only capture a subset of a fragment mass and velocity generated by a blast event. I investigated these limitations in a rigorous manner, then determined the effect on studies using the Army's standard crew casualty assessment tool, Operational Requirement-based Casualty Assessment (ORCA).

BRL-CAD Analog-To-Digital Video Conversion Remastering

Weaver, Stephanie N.

Survivability Lethality Analysis Directorate (SLAD) has used multiple tape formats which, over time, have collected dust and moisture, and some have become distorted by the pull of gravity. To ensure the preservation of this valuable SLAD historical data, I created a database with archival information for easy retrieval of these tapes. The location, title, and format of each tape was entered into the database, then using specific players, I reviewed the tapes and noted their contents and relevance to the Ballistic Research Laboratory Computer-Aided Design (BRL-CAD) tool (SLAD's geometric-based modeling system). I verified and categorized the tapes by common content and reviewed their differences; all this information was recorded into the database. An Advanced Digital Video Convertor (ADVC)700 was purchased; I set up the ADVC and converted the tapes from an analog to digital signal format, uploaded them onto my computer, and edited the clips with Final Cut Pro, a powerful, high-performance editing software tool. The finished products were saved for access through an archive.

Tensile Properties of Steel Alloys as a Function of Strain Rate and Temperature

Wei, Lawrence

In this experiment, I explored the strain rate and temperature response of two steel alloy materials, M107 and SA-M1A1, under uniaxial tensile testing in order to better understand their deformation and failure behaviors. I tested the specimens using strain rates of 0.001/s, 0.1/s, and 1000/s at room temperature, and a strain rate of 0.1/s at 20 °C, 100 °C, and 180 °C. I used an Instron servo-hydraulic machine for the low (.001/s) and intermediate (.1/s) strain rate conditions as well as all of the elevated temperature experiments, and a modified split Hopkinson pressure bar (SHPB) to perform the tensile loading for the high rate tests. According to the experimental results, the yield stress increased with increasing strain rate and decreasing temperature. However, I was unable to obtain a definitive verdict on the two steels' failure strain response as a function of strain rate and temperature. The collected data showed no correlation between failure strain and changes in strain rate and temperature. In this paper, I explain this finding in detail.

Novel Thin Film Materials for Tunable Device Applications

Weiss, Claire

The morphology and dielectric properties of Barium Strontium Titanate ($Ba_{0.6}Sr_{0.4}TiO_3$ or BST) thin films were studied as a function of film thickness. The films were prepared by metalorganic solution deposition (MOSD), and the BST precursor solution was then spin-coated onto platinum silicon wafers. The thin films were then characterized using a field emission scanning electron microscope (FESEM), an atomic force microscope (AFM), Rutherford back-scattering (RBS), and dielectric and electrical measurements. The dielectric constant varied with film thickness and was largest for the thickest film (ε_r=503), with a nominal thickness of 400nm. However, the loss tangent was also highest for this film at 0.045. Overall, the best combination of dielectric properties is found in the medium-thickness films, with a thickness ranging from about 160nm to 240nm. These films had a dielectric constant near 300, loss around 0.03, and tunability up to 30%. These findings show that careful thickness control of BST thin films may be a useful method to obtain the desired dielectric properties necessary for tunable devices.

The author wishes to acknowledge the mentorship of Dr. Melanie Cole.

Army Research Lab IT Support

West, Alexander

When U.S. Army Research Laboratory (ARL) employees experience computer related problems, they contact the ARL Information Technology (IT) support team through the ARL Helpdesk. Our team then promptly responds and assists the user in any way needed. During my summer break and my part-time employment throughout the school semester, I assisted our team in completing the tasks necessary to satisfy the customers IT needs. These tasks included installation, replacement and removal of hardware, software maintenance and support, and also expansion and modification of the network. While working with the support team, I gained substantial knowledge and experience regarding customized software development and maintenance, database development tools, operating systems, backup and recovery, PC systems support, optimization, desktop administration, and computer security.

The author wishes to acknowledge the mentorship of Milton Tirado.

Measuring Full-Field Strains on the Advanced Combat Helmet (ACH)

Whittie, Stephen

I conducted side-to-side compression resistance tests on two different concepts of the Advanced Combat Helmet (ACH). This test method is one of the many criteria stated in Purchase Description CO/PD-05-04 as an evaluation of candidate helmet designs for the ACH program. The helmets were fabricated from two different materials, Kevlar and Dyneema. In addition to the tests, I used digital image correlation (DIC) to measure the full-field strains on the inner ear dome. This type of visualization measurement can offer additional insight for evaluating different helmet designs and materials.

The author wishes to acknowledge the mentorship of Paul Moy.

Hydrogen Peroxide Production in MFC Cathodes

Wong, Michael

For this experiment, I used microbial fuel cells (MFCs) with two chambers, a cathode and an anode. In an MFC, the anode is inoculated with the microorganism, *Shewanella oneidensis*, which consumes food and produces protons and free electrons. If oxygen is present in the cathode, the protons should be fully reduced to water; however, instead hydrogen peroxide is produced. The presence of hydrogen peroxide, which has a lower redox potential than water, results in lower current production when it is present in the cathode. In order to speed up the decomposition of hydrogen peroxide into oxygen and water, I added the enzyme catalase, which is found in nearly all living aerobic organisms. I then used a F.O.X. assay to determine the concentration of hydrogen peroxide after I added the catalase. My aim is to use catalase to complete the reduction reaction, thereby increasing the current production of the fuel cell.

The author wishes to acknowledge the mentorship of Dr. James Sumner.

Very Affordable Precision Projectile System (VAPPS)

Wright, James

Currently the advanced munitions concepts branch of WMRD is working on a program known as VAPPS, which is a round designed with canards located at the front of the projectile in order to increase flight time and lateral control. Since this project is still in the research and development stage, many related projects still remain to be completed. One of these projects was to show that it was possible to calibrate rate sensors using a centrifuge table. The cornerstone concept was to first prove that the tachometer output from the centrifuge was an accurate representation of the actual spin rate, and then verify it using a photo interrupter.

Using the centrifuge table in lab 1199 at the Rodman Building, I determined that although the tachometer was not 100% accurate, it did follow a linear trend, meaning that a calibration equation could be calculated in order to correct the output data. I then used this calibration to calibrate a rate sensor based on the tachometer output. Once again, the data followed a linear trend, but there were some errors, which could be accounted for by the uneven weight distribution on the table. All in all, this experiment proved that it is possible to calibrate rate sensors using a centrifuge table.

The Smart UPS

Wright, Jereme

The Network at ALC is in the first year of upgrading all network devices, to include the Uninterruptible Power Supplies (UPSs). In my internship I learned how to install, configure and replace remote UPS management cards and batteries in the chassis. A UPS is essentially a cabinet that is capable of supplying and maintaining power (240 Volts) in the event of a power disruption or blackout. In order to configure, you have to give the UPS card an IP address. I learned about subnetting, which breaks down the IP addresses into smaller Virtual LANs. I also learned the INI file in order to configure the UPS card. In addition, I reset UPS cards and installed UPS units and APC servers in data closets in various buildings at ALC and at Blossom Point. Subsequent to the installment, I would remotely configure the UPS card over the LAN, to get the correct settings, I queried the ARL DNS server for correct IP addresses and host names.

The author wishes to acknowledge the mentorship of Kojo Addae-Mintah.

Beam Propagation Model of a Resonantly Pumped Solid-State Erbium (Er) Laser

Yip, Wendy

I developed a 2-dimensional (x,z) beam propagation method using Matlab software to solve the paraxial wave equation inside a laser cavity. A Crank-Nicholson finite difference scheme takes the values of the field in a transverse plane and calculates the field in the next plane. I set up an iterative scheme to allow the beam to propagate through the cavity. Propagation continues until the solution converges. As the oscillation in the cavity builds up, the gain decreases due to saturation. I determined the gain coefficient of an erbium substituted: yttrium aluminum garnet (Er:YAG) laser by solving the population density of equations of Er.

The author wishes to acknowledge the mentorship of Jeff White.

Dynamic Fracture in Glass

Zumbrum, John; Bjerke, Todd

We conducted an experimental effort to understand dynamic crack propagation in soda-lime glass panels. To generate mode I dominant cracking, we impacted single edge, notched fracture specimens, examining, in particular, the transition from smooth surface (mirror) crack growth to rough surface (hackle) crack branching. This paper includes a detailed discussion of the critical aspects of obtaining experimental data. We also present and compare the crack surface morphology and finite element simulation results.

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